Quantum Institute Workshop

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Quantum Degenerate Matter

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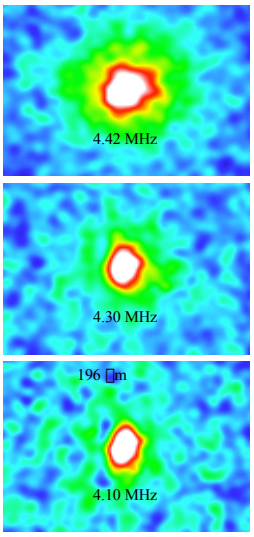
MOTIVATION

- Use Feshbach resonance to control atom-atom interaction -> increase critical temperature (T_c) for Cooper pairing transition to superfluid state
- Observe Josephson-like oscillations between atomic (fermionic) and molecular (bosonic) population
- Test BCS theory in weak interaction limit



LANL BEC

^{84}Rb - ^{87}Rb SYSTEM

- Sympathetic cool radioactive ^{84}Rb ($t_{1/2}$=33 d) fermions with ^{87}Rb BEC
- Good collision properties calculated for ^{84}Rb - ^{87}Rb a_S = 117 (a.u.), a_T = 550 (a.u.)
- Feshbach resonance predicted at ~100 Gauss for ^{84}Rb (5/2, 5/2) and (5/2, 3/2) states
  (Burke and Bohn, PRA 59, 1303 (1999))
- Mixtures of ^{84}Rb - ^{87}Rb already trapped
  (S.G. Crane *et al.*, PRA 62, 011402R (2000))
- ^{87}Rb recently cooled to BEC @ 50 nK in a TOP magnetic trap

Quantum Entanglement of Atoms in an Optical Lattice

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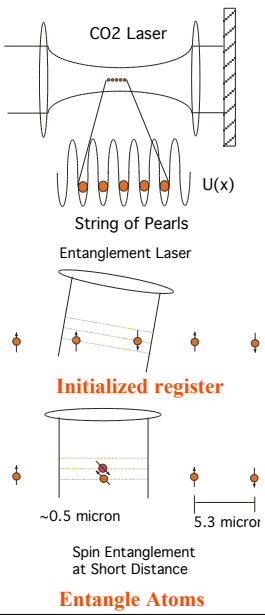

- Entangle m-states in the ground hyperfine manifold (long coherence times ~10s possible)
- Now setting up a CO_2 optical lattice (lattice spacing 5 mm) (individual addressing and fluorescence readout)
- Transfer atoms to another lattice formed by Ti:S laser to do spin-spin entanglement (1 s EPR entanglement rate)
- Feshbach resonance can also be used for faster spin entanglement (10-100 ms entanglement rate)
- Study decoherence effects, multi-quantal entanglement, quantum gates, etc.

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